Generativity and imagination in autism spectrum disorder: Evidence from individual differences in children’s impossible entity drawings

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This study examined the cognitive underpinnings of spontaneous imagination in autism spectrum disorder (ASD) by way of individual differences. Children with ASD (N = 27) and matched typically developing (TD) children were administered Karmiloff-Smith’s (1990) imaginative drawing task, along with measures that tapped specific executive functions (generativity, visuospatial planning, and central coherence processing style) and false belief theory of mind (ToM) understanding. The ASD group drawings displayed deficits in imaginative content and a piecemeal pictorial style. ASD participants also showed group deficits in generativity, planning and ToM, and exhibited weak coherence. Individual differences in generativity were related to imaginative drawing content in the ASD group, and the association was mediated through planning ability. Variations in weak coherence were separately related to a piecemeal drawing style in the ASD group. Variations in generativity were also linked with imaginative drawing content in the TD group; the connection unfolded when it received pooled variance from receptive language ability, and thereupon mediated through false belief reasoning to cue imaginative content. Results are discussed in terms of how generativity plays a broad and important role for imagination in ASD and typical development, albeit in different ways.

There is one group of individuals for whom spontaneous and fantastical acts of imagination appear to be a formidable challenge: children with autism (CWA). While there has been prolific research on social interaction and communication in autism, research focusing on cognitive processes underpinning acts of imagination has been less prominent (Frith, 2003).

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**Imaginative drawings**

Scott and Baron-Cohen (1996) proposed that the ability to represent fantastical entities that do not exist except in our own minds may involve a distinct neuro-cognitive mechanism that is selectively impaired in autism. They assessed imagination deficits in autism through Karmiloff-Smith’s (1990) ‘Draw an Impossible Person’ task. CWA, in contrast to typically developing (TD) children and children with moderate learning disability (MLD), failed at drawing impossible pictures. Ninety-two percent of the CWA group drew real looking people instead. These results were replicated by Craig, Baron-Cohen, and Scott (2001) with children on the higher-functioning subgroup on the autistic spectrum of Asperger’s Syndrome. Against the pattern of findings from Baron-Cohen and his colleagues, Leevers and Harris (1998) using a picture completion task reported that all groups (TD, CWA, and MLD) accurately applied patterns that would classify a drawing as being impossible looking (e.g. colouring a snowman black).

Baron-Cohen and his colleagues (e.g. Craig et al., 2001; Scott & Baron-Cohen, 1996) suggested that their observations of autism spectrum disorder (ASD) impairments in imaginative drawing attempts can be viewed as expressions of deficits in understanding how beliefs can be decoupled from reality, which are linked to theory of mind (ToM) mechanism abnormalities. In contrast, Leevers and Harris proposed that the difficulty for CWA lies in carrying out visuospatial plans to produce an entire novel drawing rather than in imagination or mental state understanding. In reply, Baron-Cohen and his colleagues contended that Leevers and Harris’ tasks may have been too easy and argued that if there is an imaginative impairment *per se*, the task focus should be on spontaneous drawings where children are required to explicitly manipulate knowledge structures in hypothetical ways. The flagship studies by Scott and Baron-Cohen (1996) and Leevers and Harris (1998) concentrated only on demonstrating or challenging the magnitude of ASD group impairments in imagination against background research on ToM versus executive dysfunction. If a particular cognitive deficit is principally responsible for imagination impairments in ASD, then variance in the display of that cognitive skill should be related to the extent and variability of imagination shown.

**The present study**

Our main issue of interest was to assess the putative links between individual differences in the ability to represent imaginative drawing content with executive function versus ToM using correlational analyses. Based on Scott and Baron-Cohen’s (1996) contention that imagination impairment may be a reflection of deficits in mental state understanding, variation in false belief attribution should be related to individual differences in imaginative drawing content in our ASD group. However, several lines of evidence qualify against such an expectation.

First, the developmental literature on pictorial skills indicates that even young TD children can, through example priming, show above average performance in the range and complexity of imaginative ideas depicted (e.g. Hollis & Low, 2005; Low, 2006; Zhi, Thomas, & Robinson, 1997). Group differences in the application of imaginative drawing ideas between ASD and TD children can even disappear under prompted conditions (e.g. Leevers & Harris, 1998). Second, various measures of language ability have been found to correlate with standard false belief ToM measures, in both ASD and in typical development (e.g. Fisher, Happé, & Dunn, 2005; Milligan, Astington, & Dack, 2007). Fisher *et al.* reported that the correlation between receptive grammar ability and false belief comprehension is even stronger in ASD than in normal development.
They suggested that CWA use and depend on language as a focal point to scaffold mental state understanding. Such evidence implies that the strength of the contended ASD association linking false belief mental state understanding and imagination may become non-significant once variance due to receptive language (and chronological age) is removed. Furthermore, while there is a strong association between language and executive function in typical development (e.g. Hughes, 1996), children with ASD do not appear to reliably use or depend on language for the service of executive control (e.g. Joseph, McGrath, & Tager-Flusberg, 2005; Russell, 1997). These findings, in turn, suggest that variations in executive function would remain uniquely related to the display of imagination in ASD even after variance due to receptive language (and chronological age) is partialled out. Consequently, we expected that variations in imaginative drawing content would be uniquely tied to executive function performance for our ASD group relative to our TD control group. The study of executive function in relation to imagination in ASD must be constrained because executive control as a construct on its own is too broad. It is important to be clear about mechanisms underpinning achievements in creative thought. There is evidence delineating at least two specific executive processes that may be important for imagination in ASD: generativity and planning.

In the related area of pretend play in ASD, Turner (1997) argued that generativity, the ability to generate novel ideas, is a key locus of difficulty where virtual symbolic production is concerned. Turner maintains that difficulties in generating hypothetical schemes necessary for flexible thought is able to capture the heterogeneity that exists in the display of imagination in ASD, as impaired generativity would have implications at all levels of behaviour. Her theoretical position is supported by several lines of evidence indicating that: (1) CWA produce pretend play acts at a slower rate than control counterparts (e.g. Jarrold, Boucher, & Smith, 1996) and (2) external prompts can help CWA engage in pretence and entertain counterfactual propositions (e.g. Lewis & Boucher, 1988). Further relevance of generativity for spontaneous imagination via drawings comes from studies by Lewis and Boucher (1991) and Turner (1999). Lewis and Boucher found that the successive pictures of everyday objects produced by CWA showed a high degree of thematic relatedness, as compared to control participants. Turner also uncovered that CWA of different ability levels were more likely than control participants to generate fewer novel responses when attempting to produce as many interpretations as possible from meaningless two dimensional patterns. The salience of generativity for flexible symbolic production in ASD has primarily been tested and supported with respect to pretend play (Rutherford & Rogers, 2003). Scott and Baron-Cohen (1996) reported that generativity deficits did not occur alongside failures at producing impossible entity drawings in their autism group. However, their findings are difficult to resolve as they only used one item from the uses of objects generativity task (novel uses for a brick) (Lezak, Howieson, & Loring, 2004). Given Turner's (1999) comprehensive study showing ASD deficits in naming novel uses for a diverse set of given objects and also deficits in producing daring interpretations of line drawings, we predicted that variations in generativity would relate to individual differences in imagining unreal things in ASD.

The relationship between generativity and imagination in ASD could, however, be mediated by a third factor. Leevers and Harris (1998) have specifically postulated that spontaneous imaginative drawings are difficult for CWA because such displays require the micro-deployment of new and potentially complex visuospatial plans; consequently, participants may instead re-execute easy and already familiar graphic procedures.
Their reasoning fits with research on drawings by TD children showing that visuospatial planning (e.g. shape contrast, axis orientation) is an important control factor that is involved in novel picture production (e.g. Freeman, 1987; Low & Hollis, 2003; Thomas & Silk, 1990). CWA’s success with imaginative picture completion tasks that have reduced planning demands also dovetails with research showing that such children have specific group deficits on measures of visuospatial planning (e.g. Prior & Hoffmann, 1990). Accordingly, even if individuals with ASD are able to generate imaginative drawing ideas, those ideas may not be graphically translated on paper without a certain degree of visuospatial finesse. We predicted that for our ASD group, as compared to our TD control group, variations in generativity would relate to individual differences in imaginative drawing ability and the relationship would be mediated through variance in visuospatial skills.

Impairments in generativity and planning are undoubtedly not able to account for all aspects of imaginative drawing behaviours in ASD. For example, it is difficult for a generativity based account to explain why children with ASD, compared to TD children, tend to pursue drawings of everyday objects by beginning with local features and completing them in a non-sequential manner (e.g. Booth, Charlton, Hughes, & Happé, 2003). In Booth et al.’s study, the extent of the circumscribed drawing style of the ASD participants was even unrelated to their planning abilities. Such presentations appear to fit with predictions made by Happé (2003) whereby the concept of (weak) central coherence captures visual and spatial processing styles associated with the disorder, and explains superiority in tasks where local processing is advantageous. The relevance of generativity and planning along with weak coherence for imaginative drawing behaviours in ASD are clearly not mutually exclusive. Following Turner (1997), we argue that variations in imaginative drawing ability that are shaped by executive functioning weaknesses in generativity and planning may also be maintained by executive strengths towards weak central coherence. We predicted that while generativity and visuospatial planning abilities would relate to the extent of imaginative drawing content produced by children with ASD, those children’s individual biases towards weak coherence would link specifically with drawing style.

In our study, we measured imagination in ASD through Karmiloff-Smith’s (1990) drawing task. An unprompted task protocol was used as Baron-Cohen and colleagues have maintained that impairments in representing non-veridical content can only be detected and understood through such a procedure. However, findings revealed through an unprompted procedure could still converge with research suggesting that executive functioning has considerable performance-competence implications for imagination, especially if we uncover, as was hypothesized here, that variations in impossible entity drawings produced by children with ASD would be most strongly associated with generativity, planning, and weak coherence style.

**Method**

**Participants**

Participants in the ASD group were independently diagnosed and confirmed with either autism ($N = 18$) or Asperger’s syndrome ($N = 9$) using *Diagnostic and Statistical Manual* – 4th ed. criteria by at least two of a clinical psychologist, paediatrician and a speech pathologist. Participants were recruited through specialist mental health units around Wellington in New Zealand. The ASD group in this study consisted of
27 participants (23 males) with a chronological age range of 5.25–13.08 years ($M = 8.26$ years; $SD = 2.17$). The mean chronological age (along with standard deviation and range) of our ASD group was in line with the participant characteristics of Scott and Baron-Cohen (1996) and Leevers and Harris (1998). The verbal mental age (VMA) of the ASD group ranged from 4.00 to 10.83 years ($M = 6.29$ years; $SD = 2.23$). The TD control group participants were recruited from primary schools in Wellington.

Participants in the TD group were chosen to match participants in the ASD group on VMA and gender. Participants in the TD group ($N = 27$; 23 males) aged between 4.50 and 10.67 years ($M = 6.60$ years; $SD = 1.31$). The VMA of the TD group ranged between 4.00 and 10.83 years ($M = 6.16$ years; $SD = 2.09$). Participants in the ASD group were older than those in the TD group, $F(1, 52) = 11.70$, $p < .001$. The absence of significant differences on VMA ($F(1, 52) = 0.05$, $p > .05$) was consistent with groups being matched on this variable.

Measure of VMA and receptive language ability
Receptive language ability was assessed using the TROG-2 (Bishop, 2003). Scores on number of blocks passed were converted to VMA scores, according to instructions in the manual. Previous studies on imaginative drawings in ASD have used the TROG to match groups in terms of VMA (e.g. Leevers & Harris, 1998; Scott & Baron-Cohen, 1996). Drawing from Fisher et al. (2005), raw TROG-2 scores of receptive language ability were used in correlation analyses to clarify the relationship between cognition and imagination.

Measures of executive function
Generativity; uses of objects and pattern meanings tasks
The two tasks, uses of objects and pattern meanings, were taken from Turner’s (1999) study measuring the ability to generate diverse novel ideas in autism. Bishop and Norbury (2005) recently confirmed that a combined score as derived from these two tasks is especially sensitive towards detecting weaknesses in generativity in autism. In the uses of objects task, participants were shown one object at a time and asked to generate uses for which it could be put: a brick; a cup; a pencil; a piece of doweling; a piece of fabric; and a piece of elastic. The first three objects had obvious conventional uses while the latter three did not. Order of presentation of conventional and non-conventional objects was counterbalanced, but within each object group, the order of items remained the same. For each conventional item, a typical use (e.g. a cup could be used to drink from) and a novel use (e.g. a cup could be used as a doll’s hat) were given. For each non-conventional item, a novel use was suggested (e.g. a piece of elastic could be used as a catapult). Following the example suggestions, participants were invited to: ‘tell me all the other ways you think a [object] could be useful’. Participants were given 2½ minutes for each object. Following Bishop and Norbury, each idea was coded as either a correct response (a plausible use, such as using a piece of cloth to make a doll’s shirt), an incorrect response (a vague or implausible use, such as eating the brick), a repetition (identical to a previous response for that specific item or any previous item), a redundant response (varying in some small way from a previous response, such saying a brick could be used to make a shed after saying it could be used to make a house) or a not-useful response (such as carry the brick).
The second generativity task, pattern meanings, used five meaningless line drawings, each printed on separate pieces of paper. Each participant was presented with one practice item and five test items. For the practice item, the experimenter asked, ‘What could this look like?’ Responses were praised and other suggestion prompts were offered such as: ‘a hedgehog’ and ‘a brush’. Participants were then shown the test stimuli one by one, and for each design were asked to think of as many things as possible that it could be. Each participant was given $2\frac{1}{2}$ minutes to respond to each item. Bishop and Norbury’s (2005) scoring instructions were adopted and responses were coded as a correct response (a plausible interpretation), an incorrect response (a vague or implausible interpretation), a repetition or a redundant response.

Agreement between two independent raters coding over 1,500 responses was 90% for the uses of objects and 94% for the pattern meanings tasks. All differences were resolved upon discussion. In agreement with Bishop and Norbury (2005), there was a significant correlation between the uses of objects and pattern meanings tasks for the proportion of correct responses ($r = .47$, $N = 54$, $p < .001$). Following Bishop and Norbury, then, the mean proportion of correct responses across both tasks was taken as a measure of generativity.

Visuospatial planning; mazes task
This task was taken from the Wechsler Intelligence Scale for Children (WISC-III; Weschler, 1992). Following instructions in the manual, scores for each maze were determined according to the number of errors made. High scores indicated good visuospatial planning ability (max score = 28 points). Wechsler’s mazes has been used to measure visuospatial planning ability in TD and ASD groups (e.g. Pellicano, Maybery, Durkin, & Maley, 2006).

Central Coherence; Children’s Embedded Figures Test
The Children’s Embedded Figures Test (CEFT; Witkin, Oltman, Raskin, & Karp, 1971) was used to gauge the level at which participants showed a bias in information processing style towards weak coherence. Following Pellicano et al. (2006), participants were shown a cardboard cut-out of a target shape and asked to find the same target shape hidden within the larger complex picture as quickly as they could. Also following Pellicano et al., a maximum of 30 seconds was allowed to successfully complete each trial. If a particular trial was not completed within this time limit, a score of 30 seconds was recorded for that trial. By averaging latency times across all 25 trials, a mean score was calculated, with a low score indicating a tendency for weak coherence.

Measures of theory of mind
The ToM task battery comprised one trial of the unexpected transfer (Sally–Anne) first-order false belief task (Baron-Cohen, Leslie, & Frith, 1985), one trial of the unexpected contents (smarties) first-order false belief task (Gopnik & Slaughter, 1991), and one trial of the John–Mary second-order false belief task (Baron-Cohen, 1989). All tasks were acted out with dolls and props. In the unexpected contents task, participants were asked both about another doll’s and their own false belief. In the second-order task, participants were asked about a character’s false belief and to justify it. Hence, across all ToM tasks, we asked a total of five false belief questions (one for the unexpected transfer task, two for the unexpected contents task, and two for the John–Mary task).
Participants passed the control questions found in these tasks. Following Baron-Cohen’s (1989) scoring details, participants’ answers to the false belief justification question in the second-order task were coded into one of three categories according to whether the participant accounted for: (a) John and Mary’s beliefs (second-order; 2 points); (b) John or Mary’s beliefs (first-order; 1 point); or (c) neither of the characters’ beliefs (zero-order; 0 points). Two raters blind to group diagnosis coded the justification responses with 100% reliability. Points across the first-order false belief questions (maximum score of 3) and second-order false belief questions (maximum of 3) were summed to give a composite ToM score ranging from 0 to 6. Whilst the composite score allowed us, to a certain extent, to take into account the continuous nature of ToM development, we also analysed performance on first- and second-order false belief understanding separately.

**Measure of imaginative drawing**

Imagination was measured using Karmiloff-Smith’s (1990) drawing task. Following Hollis and Low’s (2005) lead, we slightly modified the presentation context of the Karmiloff-Smith task to make clear its requirement. Participants were first shown a picture of people walking towards a sparkling door that opened on to a path leading to a distant planet in space. The scene was set as follows. ‘These people are walking through a magic door that sends them to live on a faraway different planet in space. When people walk through the door, they get magically changed into funny, strange looking people that no one has ever seen before. Draw as many pictures as you can of what people coming out of the door would look like, making the changed people look as funny and strange looking as you can.’ Hollis and Low argued that such minor modifications to the context of the drawing task helps children understand the task without sacrificing the essential structural requirement of explicitly manipulating knowledge to entertain and produce non-veridical content. We further reasoned that the use of scores based on the proportion of imaginative ideas averaged over several drawings would increase the reliability of our behavioural measure relative to prior studies that operationalised their dependent measure of the ability to represent imaginative content based on a single drawing (e.g. Scott & Baron-Cohen, 1996). Participants were instructed to depict each drawing on a separate piece of paper. Each drawing was taken away after it was finished. No time limit was imposed.

The experimenter also discretely recorded what feature of the picture was drawn first, what feature was drawn second, third, and so on. The recordings of the entire drawing process by the experimenter was labour intensive but was necessary as the comprehensive notes about the organization of the drawing enabled us to carefully determine whether children started their drawings with local or global components, and whether children structured their drawings in a sequential fashion. After the drawings were completed, when participants indicated that they could not think of anything else to draw, the experimenter invited participants to describe the content of each drawing that had been produced. All responses were praised and recorded. In this manner, we had ample data describing the content of each drawing, and also how the drawing itself stylistically unfolded.

We also checked, after children finished the imaginative drawing task, whether participants were able to draw a normal looking human figure. All participants were able to do so. Such checks allowed us to confirm that the content coded in the pretend people drawings did indeed constitute novel and imaginative changes. Example drawings produced by participants in the ASD group for the imagination task are shown
in Figure 1. We will explicate the coding of imaginative content by way of these example drawings.

Each feature drawn was coded according to whether or not it was imaginative. Following scoring criteria and techniques used by Marsh, Landau, and Hicks (1996), dividing the number of features that were imaginative by the total number of features drawn constituted the proportion of imaginative content for each picture. For example, one ASD participant drew a man with antennae as his pretend looking person (see Figure 1A). In this case there were a total of six main features: the head, face, body, arms/hands, legs/feet, and antennae. There was only one imaginative feature, the antennae. Hence, the proportion of imaginative content for that drawing was 0.17 (1/6). Another ASD participant described his drawing of a pretend looking person as having ‘fire on his head, and has claws all over his arms and legs’ (see Figure 1B). Correspondingly, there were three imaginative features (targeted to the head, arms/hands, and legs/feet) and two standard features (the face and body), and the proportion of imaginative content was calculated as 0.6 (3/5). As the examples in Figure 1A and 1B show, successful instantiations of pretend looking people ‘introduced appropriate changes while simultaneously retaining core concepts of personhood’ (Karmiloff-Smith, 1990, p.62). When participants instead drew real people for their imaginative drawings, with standard looking heads, faces, arms/hands, bodies, and legs/feet (see Figure 1C), then the proportion of imaginative content was 0 (0/5). In this manner, the proportion of imaginative content was calculated for each drawing produced by participants in the ASD and TD groups. Then the overall mean proportion of imaginative content drawn was calculated for each participant by averaging the proportion scores across all drawings produced.

Overall agreement between two independent raters coding across all drawings was 90%. Superficial changes that were possible in reality (e.g. hairstyle) did not constitute as imaginative features. Drawings of completely different but real entities (e.g. animals at the zoo) were also not considered as successful non-veridical instantiations. In these cases, participants received a zero score for the proportion of imaginative content found in those respective drawings.

Aside from extent of imagination, we also analysed the drawings produced in terms of style. Two dimensions of style were coded: the initial feature drawn and fragmentation. Following the coding criteria set up by Booth et al. (2003), for each

Figure 1. Example pictures produced by participants in the ASD group showing varying proportions of imaginative content.
drawing, initial features were scored on a three point scale. Two points were given when a local feature was drawn first, and one point was allocated when a local feature was the second thing drawn. Zero points were given when a global feature was drawn first. Figure 2 shows an example of a drawing from a participant with ASD scoring two points for the initial feature dimension.

Using notes accompanying each picture specifying the drawing process, two independent raters reached 93% agreement on coding of initial features. All differences were resolved upon discussion. Averaging across drawings, all participants received a mean initial feature score.

The second dimension of drawing style we coded was fragmentation. Following Booth et al. (2003), fragmentation was scored on a three point scale from highly fragmented (2 points) to not at all fragmented (0 points). We also used their operationalisation of fragmentation as being ‘the degree of disjointed appearance, separation of parts or drawing style that was not sequential’ (p. 389). To illustrate, the example drawing shown in Figure 2 scored two points for fragmentation. Again, with recourse to the notes accompanying each picture specifying the drawing process, two independent raters reached 89% agreement on coding of fragmentation. All differences were resolved upon discussion. Averaging across drawings, all participants received a mean fragmentation score. We summed scores across both dimensions (initial feature and fragmentation) to give each child a drawing style score (maximum total of 4) whereby the higher the score, the greater the tendency to adopt a weak coherence graphic style (Booth et al., 2003).

**Procedure**

All participants were seen individually by an experimenter in a quiet room at home (for the ASD group) or at school (for the TD group). All tasks were administered in around four 0.5- to 1-hour sessions that were approximately 1 week apart. Order of tasks was semi-random so that it was comparable across groups. Due to the time involved for TROG-2, this measure was administered first. In the second session, the imaginative drawing task was administered alongside the ToM tasks. Also during the second session, the normal person drawing check was given after the imaginative drawing task (in this manner, we avoided prepotent canonical human figure drawing activations from spilling into the imagination task). The planning and central coherence tasks were given at the third session. The generativity tasks were presented at the final session.

![Figure 2](image)

**Figure 2.** Example showing the temporal unfolding of a drawing from participant with ASD scoring 2 for each of the weak coherence style ratings: initial feature and fragmentation.
Heightened imaginative responding from the drawing task should have faded by the last session so as not to bias performance on the generativity tasks.

**Results**

**Group differences**

The group means ($M$), standard deviations ($SD$), and 95% confidence intervals ($CI$) on key measures of interest are provided in Table 1. Prior to conducting a multivariate analysis of variance (MANOVA), the Mahalanobis distance procedure (set at $p < .001$) (Tabachnick & Fidell, 2001) was used to identify outliers. No multivariate outliers were identified, for the ASD or TD groups. The results of the MANOVA that included all key measures revealed a significant overall group difference ($F(11, 42) = 4.01, p < .01; \eta_p^2 = .51$, observed power = 0.99).

<table>
<thead>
<tr>
<th></th>
<th>ASD</th>
<th>TD</th>
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<tbody>
<tr>
<td><strong>Number of drawings</strong></td>
<td>2.63 (1.21) [2.17 to 3.09]</td>
<td>2.78 (1.19) [2.31 to 3.24]</td>
</tr>
<tr>
<td><strong>Imaginative content</strong></td>
<td>0.32 (0.31) [0.22 to 0.43]</td>
<td>0.55 (0.22) [0.44 to 0.65]</td>
</tr>
<tr>
<td><strong>Drawing style</strong></td>
<td>1.09 (1.52) [0.65 to 1.52]</td>
<td>0.15 (0.47) [-0.28 to 0.58]</td>
</tr>
<tr>
<td><strong>Generativity</strong></td>
<td>0.52 (0.20) [0.45 to 0.59]</td>
<td>0.62 (0.16) [0.55 to 0.69]</td>
</tr>
<tr>
<td><strong>Visuospatial planning</strong></td>
<td>13.11 (6.40) [10.91 to 15.31]</td>
<td>16.70 (4.89) [14.51 to 18.90]</td>
</tr>
<tr>
<td><strong>Central coherence</strong></td>
<td>10.60 (4.16) [8.85 to 12.36]</td>
<td>13.19 (4.90) [11.44 to 14.95]</td>
</tr>
<tr>
<td><strong>Composite ToM</strong></td>
<td>2.15 (2.03) [1.41 to 2.89]</td>
<td>3.81 (1.78) [3.08 to 4.55]</td>
</tr>
<tr>
<td><strong>First-order ToM</strong></td>
<td>1.63 (1.28) [1.23 to 2.03]</td>
<td>2.59 (0.69) [2.20 to 2.99]</td>
</tr>
<tr>
<td><strong>Second-order ToM</strong></td>
<td>0.48 (0.94) [0.04 to 0.93]</td>
<td>1.19 (1.33) [0.74 to 1.63]</td>
</tr>
</tbody>
</table>

Follow-up one-way ANOVAs were performed to test differences between the ASD and TD groups on individual variables. These results were reconfirmed via pairwise comparisons with Bonferroni adjustments. There was no group difference in the actual number of pictures attempted for the imaginative drawing task, $F(1, 52) = 0.21, p > .05$. All participants in both groups provided an initial drawing attempt. With respect to the initial attempt, 93% of the TD group and 59% of the ASD group managed to produce a picture with impossible features. At least half of the participants in both groups also attempted a second and third drawing for the imagination task. For participants who attempted a second drawing, 100% (21/21) of the children in the TD group included imaginative features while 68% (15/22) of children in the ASD group did so. For participants who attempted a third drawing, 100% of the children in the TD group (19/19) included imaginative features while 73% of the children in the ASD group (11/15) did so. Overall, at the level of extent to which each picture is impossible, the ASD group included proportionally fewer imaginative features averaged across their drawings as compared to the TD group, $F(1, 52) = 9.40, p < .01$. We also checked that the lower rate of imaginative drawing content in the ASD group was not because the children provided more non-imaginative features overall – the amount of non-imaginative drawing content did not differ between-groups ($F(1, 52) = 0.42, p > .05$; $MASD = 0.53$; and $M_{TD} = 0.49$). Finally, the drawings produced by the ASD group
showed more of a local coherence graphic style compared to the TD group, $F(1, 52) = 9.36, p < .01$.

Compared with the TD group, children in the ASD group had significantly lower generativity scores ($F(1, 52) = 4.15, p < .05$) and lower visuospatial planning scores ($F(1, 52) = 5.37, p < .05$). The ASD group displayed significantly faster times on the embedded figures task (showing weaker coherence) compared to the TD group ($F(1, 52) = 4.38, p < .05$). Also against the TD group, the ASD group obtained significantly lower composite scores on the ToM battery ($F(1, 52) = 10.29, p < .01$); the difference remained when the battery was separated into first- ($F(1, 52) = 11.88, p < .01$) and second-order false belief tasks ($F(1, 52) = 5.05, p < .05$).

*Prominence of executive functions in relation to imaginative drawing behaviours*

Associations involving executive function and ToM with imaginative drawing were examined for the ASD and TD groups separately.

**ASD group**

The significant associations found for the ASD group (full and partial) are reported in Table 2. Table 2 also includes associations amongst executive function, ToM and receptive language ability. In keeping with the primary focus of our study, we necessarily limit our results section to explaining correlations relevant to imaginative drawing behaviours. However, we will weave into our discussion those other co-occurring relationships where they might assist in illuminating the cognitive processes underpinning imagination.

**Table 2.** Significant correlations (bivariate and full partial with CA and receptive language controlled) for the ASD group (all other comparisons were not significant)

<table>
<thead>
<tr>
<th>ASD associations</th>
<th>Full bivariate</th>
<th>Full partial</th>
</tr>
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<tbody>
<tr>
<td>CA and receptive language</td>
<td>.42*</td>
<td>–</td>
</tr>
<tr>
<td>CA and generativity</td>
<td>.50***</td>
<td>–</td>
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<tr>
<td>Receptive language and composite ToM</td>
<td>.63****</td>
<td>–</td>
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<tr>
<td>Receptive language and first-order ToM</td>
<td>.59**</td>
<td>–</td>
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<tr>
<td>Receptive language and second-order ToM</td>
<td>.52**</td>
<td>–</td>
</tr>
<tr>
<td>Receptive language and generativity</td>
<td>.51***</td>
<td>.55**</td>
</tr>
<tr>
<td>Generativity and imaginative content</td>
<td>.65****</td>
<td>.55**</td>
</tr>
<tr>
<td>Generativity and visuospatial planning</td>
<td>.58**</td>
<td>.53**</td>
</tr>
<tr>
<td>Generativity and composite ToM</td>
<td>.44*</td>
<td>–</td>
</tr>
<tr>
<td>Generativity and first-order ToM</td>
<td>.50**</td>
<td>–</td>
</tr>
<tr>
<td>Visuospatial planning and imaginative content</td>
<td>.73***</td>
<td>.70***</td>
</tr>
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<td>Visuospatial planning and first-order ToM</td>
<td>.46*</td>
<td>.47*</td>
</tr>
<tr>
<td>Central coherence and drawing style</td>
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<td>-.44*</td>
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<td>Composite ToM and imaginative content</td>
<td>.43*</td>
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</tr>
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<td>First-order ToM and imaginative content</td>
<td>.47*</td>
<td>–</td>
</tr>
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<td>Composite ToM and first-order ToM</td>
<td>.91***</td>
<td>.87***</td>
</tr>
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<td>Composite ToM and second-order ToM</td>
<td>.85***</td>
<td>.78***</td>
</tr>
<tr>
<td>First-order ToM and second-order ToM</td>
<td>.57***</td>
<td>–</td>
</tr>
</tbody>
</table>

*p < .05; **p < .01; ***p < .001.*
For the ASD group, bivariate correlations indicated that the proportion of imaginative content drawn was correlated with generativity, visuospatial planning, and composite ToM (as well as ToM decomposed as first-order tasks). However, visuospatial planning and generativity accounted for more variance towards the proportion of imaginative content drawn ($r^2 = .53$ and $.42$, respectively) compared to composite or first-order ToM ($r^2 = .18$ and $.22$, respectively). Bivariate correlations also indicated that individual differences in the stylistic manner by which drawings were produced were related to variations in embedded figures task scores (i.e. the faster the ASD children were at the embedded figures task, the more likely their drawings started with local features and proceeded in a disjointed manner). The relationship between weak central coherence and drawing style remained even after full partial correlation analysis. When the effects of receptive language ability were controlled alongside chronological age, only generativity and visuospatial planning remained associated with the proportion of imaginative content drawn. Such relationships were consistent with our other findings for the ASD group: while receptive language ability was connected to ToM; language ability was not extensively; or widely related to executive skills.

Full partial correlation analyses suggested that generativity and visuospatial planning performance were both associated with the proportion of imaginative content drawn. These results were further refined by a regression analysis conducted to examine whether generativity and visuospatial planning contributed unique variance to imaginative drawing content in the ASD group. Bivariate correlation analyses had indicated that receptive language ability was associated with chronological age in the ASD group. Hence, in the stepwise linear regression analysis, the effects of chronological age ($\beta = 0.27; p > .05$) and language ability ($\beta = 0.24; p > .05$) were jointly removed at the first step ($R^2 = .19$, $F(2, 24) = 2.75$, $p > .05$). Generativity and visuospatial planning scores were entered in the second and third steps respectively, in line with our theoretically guided hypothesis that successful solutions to Karmiloff-Smith’s imaginative drawing task may require participants to initially generate a novel idea before needing to spatially plan it (cf. Turner, 1997; Leevers & Harris, 1998). Variation in generativity was found to be a unique predictor of differences in imaginative drawing content, independent of chronological age, and language ability, $\beta = 0.61$, $\Delta R^2 = .24$, $F(1, 23) = 9.75$, $p < .01$. Visuospatial planning also accounted for further unique variance, $\beta = 0.54$, $\Delta R^2 = .19$, $F(1, 22) = 10.93$, $p < .01$. Such affirmative results on their own are still insufficient as we had, when introducing underlying mechanisms influencing imagination in ASD, specifically hypothesized that for the ASD group, visuospatial planning mediates the relationship between generativity and imaginative drawing content. Our mediation hypothesis was tested using the computer programme ‘MedGraph’ using the procedure set out for its use by Jose (2003). First, sample size and correlation coefficients between the variables of interest were entered. Second, the potential mediator (visuospatial planning) was regressed on generativity ($\beta = 0.58$, $F(1, 25) = 12.84$, $p < .001$). Third, imaginative drawing content scores were regressed on both visuospatial planning ($\beta = 0.53; p < .01$) and generativity ($\beta = 0.35; p < .05$) ($R^2 = .61$, $F(2, 24) = 18.69$, $p < .001$). The relevant regression data were entered into the ‘MedGraph’ programme which analysed for mediation. The significance of Sobel’s $z$-value = 2.41, $p < .05$, revealed full mediation; when visuospatial planning as the mediator was considered, the correlation between generativity and imaginative drawing content ($r = .65$, $p < .01$) reduced to a non-significant level ($r = .35, p > .05$) and the $\beta$ weight of the direct effect of generativity to imagination dropped to non-significance (from $\beta = 0.35$ to $0.04$, $p > .05$).
**TD group**

We now proceed to detail associations relating to imaginative drawing behaviours in the TD group. Significant correlations are reported in Table 3.

**Table 3.** Significant correlations (bivariate and full partial with CA and receptive language controlled) for the TD group (all other comparisons were not significant)

<table>
<thead>
<tr>
<th>TD associations</th>
<th>Full bivariate</th>
<th>Full partial</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA and number of drawings</td>
<td>.45*</td>
<td>–</td>
</tr>
<tr>
<td>CA and generativity</td>
<td>.41*</td>
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<tr>
<td>CA and visuospatial planning</td>
<td>.56**</td>
<td>–</td>
</tr>
<tr>
<td>CA and second-order ToM</td>
<td>.39*</td>
<td>–</td>
</tr>
<tr>
<td>Number of drawings and imaginative content</td>
<td>.45*</td>
<td>–</td>
</tr>
<tr>
<td>Receptive language and number of drawings</td>
<td>.57**</td>
<td>–</td>
</tr>
<tr>
<td>Receptive language and imaginative content</td>
<td>.46*</td>
<td>–</td>
</tr>
<tr>
<td>Receptive language and generativity</td>
<td>.70***</td>
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</tr>
<tr>
<td>Receptive language and visuospatial planning</td>
<td>.59**</td>
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<tr>
<td>Receptive language and composite ToM</td>
<td>.66***</td>
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</tr>
<tr>
<td>Receptive language and first-order ToM</td>
<td>.55**</td>
<td>–</td>
</tr>
<tr>
<td>Receptive language and second-order ToM</td>
<td>.61***</td>
<td>–</td>
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<tr>
<td>Generativity and number of drawings</td>
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<td>–</td>
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<tr>
<td>Generativity and imaginative content</td>
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<td>Generativity and second-order ToM</td>
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<td>–</td>
</tr>
<tr>
<td>Visuospatial planning and number of drawings</td>
<td>.47*</td>
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</tr>
<tr>
<td>Visuospatial planning and central coherence</td>
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<tr>
<td>First-order ToM and imaginative content</td>
<td>.71***</td>
<td>.61**</td>
</tr>
<tr>
<td>Second-order ToM and imaginative content</td>
<td>.42*</td>
<td>–</td>
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<td>Composite ToM and first-order ToM</td>
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<td>.87***</td>
</tr>
<tr>
<td>First-order ToM and second-order ToM</td>
<td>.46*</td>
<td>–</td>
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</table>

*p < .05; **p < .01; ***p < .001.

Full bivariate correlations revealed that variations in the number of pictures produced, receptive language, generativity, and ToM were all positively related to differences in the proportion of imaginative content found in TD children’s drawings. Furthermore, variations in the number of drawings produced were linked to chronological age, receptive language ability, generativity, and visuospatial planning at the bivariate level. When effects associated with receptive language ability were controlled alongside chronological age, only first-order ToM remained positively associated with the proportion of imaginative content drawn.

Overall, compared to the ASD group, the way in which imaginative drawings amongst TD children was brought about was framed against a relationally complex web entangling thought and language. For example, even with just chronological age controlled, we observed that generativity and receptive language were each related to imaginative content ($r = .47, p < .05$ and $r = .41, p < .05$, respectively) and also each related to first-order ToM ($r = .53, p < .01$ and $r = .51, p < .05$, respectively). Not only
were generativity and receptive language diversely related to other constructs, they were also positively correlated with each other when we only controlled for the effects of general maturation ($r = .65, p < .01$). Generativity coupled with receptive language ability may be a potential compound process underpinning imagination in normal development that was obscured from correlation analyses by how the two constructs share and spread their variance. Consequently, to capture strong information processing affordances provided by bidirectional interactions between generativity and receptive language ability (Bloom, 1994), we distilled a new compound construct that summed their respective $z$-scores. We then conducted a regression analysis to allow a closer inspection of whether the following were predictive of imaginative drawing content in the TD group: (1) generativity interacting with language and (2) first-order ToM. A stepwise linear regression analysis was conducted with effects of general maturation ($\beta = 0.13$) and visuospatial planning ($\beta = 0.23$) entered at the first step, $R^2 = .10$, $F(2, 24) = 1.37, p > .05$. Visuospatial planning was also jointly entered into the first step because it was correlated with chronological age, and the TD group had demonstrated superior planning skills. Variation in generativity and receptive language combined was entered in the second step and was a significant predictor of differences in imaginative drawing content, $\beta = 0.52, \Delta R^2 = .18, \Delta F(1, 23) = 5.90, p < .05$. First-order ToM was entered at the third step and was still a unique predictor of individual differences in imaginative drawing content, $\beta = 0.64, \Delta R^2 = .24, \Delta F(1, 22) = 11.35, p < .01$. As a check, we re-ran the regression analyses where, instead of an interactive compound construct, generativity and receptive language were entered as separate variables at the second step of the analyses. Separately, neither generativity nor receptive language was able to cue imagination (all $ps > .05$).

Our TD group regression findings were also framed against significant tripartite associations connecting the generativity-language compound, first-order ToM, and imaginative content. The existence of tripartite correlations suggests that mediational processes could be operating (Baron & Kenny, 1986). Compared to our theoretically predicted mediation analysis for the ASD group, testing for mediation in the TD group was data-guided. However, there is extant concurrent and longitudinal research with TD groups suggesting: (1) generativity and language can each support the display and emergence of false belief reasoning (e.g. Milligan et al., 2007; Peterson & Riggs, 1999) and (2) false belief reasoning supports creative thinking (e.g. Suddendorf & Fletcher-Finn, 1999). Consequently, we may be reasonably confident in speculating that in typical development, generativity in concert with language may be related to imagination but the effect might be an indirect one that emerges through false belief reasoning. We tested for such mediation using the ‘MedGraph’ computer programme (Jose, 2003). First, sample size and correlation coefficients between the variables of interest were entered. Second, the potential mediator (first-order ToM) was regressed on the generativity and language compound ($\beta = 0.60; F(1, 25) = 14.29, p < .001$). Third, imaginative drawing content scores were regressed on both the compound construct ($\beta = 0.17; p > .05$) and first-order ToM ($\beta = 0.61; p < .01$) ($R^2 = .52; F(2, 24) = 12.87, p < .001$). The relevant data were entered into the ‘MedGraph’ programme and the significance of Sobel’s $z$-value was $2.52, p < .05$, revealed full mediation; when first-order ToM as the mediator was considered, the correlation between the generativity-language compound and imaginative drawing content ($r = .53, p < .01$) became non-significant ($r = .17, p > .05$) and the $\beta$ weight of the direct effect of generativity and language combined for imagination dropped to non-significance (from $\beta = 0.17$ to $-0.18, p > .05$).
Despite the routes in our mediation analysis for the TD group being consistent with literature indicating that generativity and language are important to false belief reasoning, and that false belief understanding can support creative problem solving, the analysis was still *ad hoc*. Given our concurrent data, we need to be cautious by checking the potential for an initial route that begins with variation in children’s ToM supporting generativity and language ability (Perner, 1998). The possibility that generativity in combination with receptive language mediated the relationship from first-order ToM to imagination was not significant (Sobel’s $z^2$ value $= 0.88$, $p > .05$). Our overall mediation findings suggest that, amongst TD children, in order for meta-representational knowledge to be useful for processing imaginative drawing solutions, generativity and receptive language skills are needed towards scaffolding such understanding.

**Discussion**

This study makes important contributions to clarifying the relationship involving executive function versus ToM with spontaneous imagination in ASD. The proportion of imaginative drawing content found in the pictures generated by the ASD group was significantly lower compared to that of the TD group. Even at the initial drawing attempt, only 59% of children in the ASD group succeeded in producing a picture containing imaginative features, compared to 93% of participants in the TD group who succeeded in doing so. In these ways, the present results replicated Scott and Baron-Cohen’s (1996) findings of impairments in the spontaneous production of non-veridical representations amongst children with ASD. Nonetheless, in Scott and Baron-Cohen’s study, only 8% of their autism group produced a single imaginative picture. The story setting could have made our drawing task more contextually meaningful for several of the ASD participants, mapping with the suggestion that executive functioning can underpin performance in drawing impossible entities. Indeed, the results supported our hypothesis in uncovering that, in ASD, alongside group deficits in generativity and planning, variation in those executive skills (instead of mentalistic understanding) were robustly associated with differences in imaginative thinking. These results not only fit with previous research showing how generativity is implicated in play behaviours seen in autism (e.g. Jarrold et al., 1996), but also confirm Turner’s (1997) theoretical suggestion that difficulties in generating spontaneous hypothetical schemes can explain ASD heterogeneity in representational flexibility deficits that go beyond the play domain. In further support of our hypothesis, we found that the relationship between generativity and imagination in ASD were processed through visuospatial planning. Confirming Leevers and Harris’ (1998) suggestion about subprocesses involved in spontaneous imaginative drawings, planning may be implicated at several finer levels of problem solving. First, children need to construct a visuospatial representation of the generated drawing ideas in working memory. Following that, children need to execute the particular plan whilst maintaining it in working memory and matching the drawing that is unfolding in relation to the satisfaction of that plan. Without some degree of concurrent ability to graphically plan and translate the generated novel ideas for the drawing task, individuals with ASD may instead execute more familiar drawing schemes. Both generativity and visuospatial planning appear uniquely and intimately tied to imagination in ASD.

Our findings that visuospatial planning ability was related to imagination (and even linked to first-order ToM with age and receptive language controlled) in the ASD group but not in the control group tantalisingly suggest that imagination in ASD might be visualization based. Visuospatial planning bridging generativity with imaginative
drawings in the ASD group may be interpreted as some children with ASD indirectly adopting a strategy of abstracting schematic impressions of their generated ideas, and then perceptually manipulating them to allow creative solutions to be realized. Similarly, our observed relationship between visuospatial planning and first-order ToM in ASD may reflect a problem solving approach that involves image schemas (e.g. spatial map of corridors in mazes, spatial coordinates in false belief story events) being framed through simulation to allow solutions to emerge (Barsalou, 1999). The suggestion that imagery based problem solving could be adopted amongst individuals with ASD for imaginative drawing ideas would be parsimonious with our other findings that low-level perceptual biases towards weak coherence were specifically related to drawing style. Interpreted as such, visuospatial planning being part of a link that relates to imagination in ASD is broadly convergent with accounts of some individuals with ASD preferring to use a visual thinking style (e.g. Kana, Keller, Cherkassky, Minshew, & Just, 2006).

We are not, however, suggesting that the visuospatial channelling of generated ideas for imagination in ASD is always sufficient or successful. While the generation of relatively straightforward ideas for imagination may be grounded in some form of perceptual analysis, the translation and on-line monitoring of highly complex drawing solutions would severely tax the capacity limit of imagery resources in working memory (van Sommers, 1995) - this may explain why there is still an overall ASD group deficit in imaginative drawing content. Moreover, if individuals with ASD generate novel ideas at a very slow rate, there would only be a limited set of schemes to creatively draw and plan from, and individuals may in longitudinal assessments start to show repetition in their imaginative drawing ideas.

Further supporting our expectations, we found that variation in generativity did not capture the full display of imaginative drawing behaviours in the ASD group. Generativity (and planning) was related to imaginative drawing content while weak central coherence was related to a drawing style that was non-sequential and began with local features. Such findings dovetail with work by Booth et al. (2003) where planning skills were also not related to how children with ASD tended to stylistically draw real world objects. Taken together, neither generativity (with planning) nor weak coherence style can be consumed by each other. Variations in strengths towards weak coherence and weaknesses in generativity and planning may even contribute to shaping the different hierarchical levels that make up imaginative drawing production.

Our results show that variance in the degree of generativity and planning was associated with variability in imagination in the ASD group, but that variance in the degree of first-order false belief reasoning was related to imagination in the TD control group. In one sense, it could be argued that ToM is naturally and normally implicated in imagination. Understanding of mental states may not turn out to be associated with imagination in ASD because modular abnormalities in ToM could lead individuals to develop specialization in engaging generativity in relation to planning for imagination. Although compelling, this rapprochement may not be sufficiently cogent as certain findings do not easily fit into this account. First, it does not immediately explain why individual differences in executive weaknesses (generativity and planning) relate to drawing content but variations in executive strengths (local processing style) relate to drawing style. Second, our exploratory mediational analysis for the TD group suggested that the means to imagination potentially begins from relating generativity in concert with receptive (grammatical) language ability to false belief reasoning. Confidence in our data is warranted by other concurrent and longitudinal research showing that there is a stronger direction of effect from executive functioning and language to false belief
understanding than the reverse (e.g. Hughes, 1998; Milligan et al., 2007). Moreover, several individuals with ASD did exhibit first-order false belief understanding, albeit achieved through a linguistically based route (suggested via a slightly higher correlation with receptive language ability). In this case, the fact that false belief knowledge still did not correlate with imagination in ASD, suggests that individuals may have failed to apply that understanding to process imaginative thinking tasks due to parallel limitations in executive functioning skills (Zelazo & Müller, 2002). Consequently, we may extrapolate that, for individuals with ASD, spontaneous imagination may be based more upon executive routes irrespective of gained false belief understanding. Relatedly, false belief reasoning may have been used to realize imagination in typical development because individuals in the control group possessed effective executive control and can use language to service executive control. Finally, meta-representational focused accounts do not readily explain why children with ASD also show generativity impairments in reality based tasks that require action flexibility (e.g. word generation and free recall; see Boucher & Lewis, 1989).

We do not deny that false belief reasoning can serve as a process for bringing out imagination, at least in typical development. We also do not deny that mental state understanding is easier for TD children than it is for children with ASD. What is denied is that strengths and weaknesses in mentalistic understanding singularly contribute at a superordinate level to relative failures and successes in imagination in ASD and TD groups, respectively. The data across the ASD and TD groups more parsimoniously suggest that generativity is necessary for imagination but its effects may be differentially processed or routed in ASD and in typical development. Our findings that generativity is linked with planning for imagination in the ASD group but instead expressed through false belief reasoning in the control group could more generally suggest cool executive control over imagination in ASD but hot affective executive control over non-veridical representations in typical development (cf. Zelazo & Müller, 2002).

Our findings raise two exciting theoretical issues for imagination in ASD that await further investigation. First, in light of the concurrent nature of our data (and a fair number of comparisons to yield the correlations), we cannot make strong causal claims about how generativity and planning may come to be developmentally associated for imagination in ASD. Steps towards clarifying such issues could include future research examining whether training in generativity and planning are jointly necessary for prompting imagination in ASD or whether support training in either executive component could sufficiently cue imagination. Second, it is not clear whether visuospatial planning as a channel through which generativity affects imagination is unique to imagination in ASD via drawings or whether planning as a mediator may also be important for imagination in ASD via a pretend play modality. Turner (1997), whilst theoretically committed to restricted imagination as the result of impaired generativity, remains open to the possibility that different executive control mediators may be implicated for translating those novel ideas into action for different symbolic tasks.

**Conclusion**

There is an important relationship between generativity and imagination. In ASD, the relationship appears to unfold via planning, while in typical development the link seems to be expressed via consultation with receptive language and false belief reasoning. On balance, the relative means by which generativity is unpacked can contribute to explaining the extent and nature of imagination in ASD and in typical development.
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References


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